STEEL PIPE POLE BASE AND REINFORCING METHOD THEREOF

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a steel pipe pole base and a reinforcing method of the steel pipe pole base for, for example, fixing a steel pipe pole such as a street light support pole, a road sign support pole and the like to a skeleton such as road and the like.

2. Description of the Related Art

As a steel pipe pole base for fixing a steel pipe pole such as a street light support pole, a road sign support pole and the like to a skeleton made of concrete and the like, a structure constructed by welding a base plate 11 to the lower end portion of a steel pipe pole 10 and reinforcing the joint between the steel pipe pole 10 and the base plate 11 with a plurality of ribs 12, as shown in Figure 10, is generally employed. Each of the ribs is a tabular triangular rib the upper end portion of which is cut obliquely and is welded to the steel pipe pole 10 in the form of a T-joint. Then, the steel pipe pole 10 is vertically supported by fixing the base plate 11 to the skeleton with anchor bolts 15.

However, in a conventional steel pipe pole base as described above, there has been a danger that, when a bending moment is imposed on a steel pipe pole 10 due to wind, vibration or the like, a large stress concentrates on the steel pipe pole 10 near the weld toes 16 of ribs 12 and, as a consequence, the strength at the portions deteriorates due to the repeated stress. Another problem has been that structural defects are likely to occur in the boxing welded portions at the upper end portions of the ribs 12 as a result of the combined effect of the residual tensile stress and the material degradation of the heat-affected zones caused by welding heat and to cause the proof stress and the fatigue property to

deteriorate.

Those problems are common to joint structures in which reinforcing ribs are welded to structural members in the form of a T-joint and, in view of this, the Japanese Society of Steel Construction points out, in "Guidelines for Fatigue Design of Steel Structures and Its Interpretation", that a joint in which a gusset is welded by fillet welding adversely affects the proof stress and fatigue property of a steel member and therefore attention has to be paid to the design of structures.

SUMMARY OF THE INVENTION

The present invention has been established for solving the aforementioned conventional problems and providing a steel pipe pole base and a reinforcing method of the steel pipe pole base, those making it possible to: suppress the deterioration of strength in the vicinity of the weld toe of a rib even when a repeated bending moment is imposed on the steel pipe pole; and prevent the deterioration of the proof stress and fatigue property of a boxing welded portion at the upper end portion of the rib. The gist of the present invention is as follows:

(1) A steel pipe pole base reinforced with ribs welded to said steel pipe pole base in the form of a T-joint, characterized by forming peening processed portions at weld toes by ultrasonic vibration.

(2) A steel pipe pole base according to the item (1), characterized by said ribs being tabular ribs.

(3) A steel pipe pole base according to the item (1), characterized by said ribs being inverted-U or inverted-V shaped ribs bent at the upper end portions.

(4) A method for reinforcing a steel pipe pole base according to any one of the items (1) to (3), characterized by applying peening treatment to weld toes by ultrasonic vibration after said tabular ribs, inverted-U shaped ribs or inverted-V shaped ribs are welded to said steel pipe pole base in the form of a T-

joint.

(5) A method for reinforcing a steel pipe pole base according to the item (4), characterized by applying peening treatment to said weld toes by ultrasonic vibration while a load is imposed on said steel pipe pole base so as to impose a tensile stress in the direction of the steel pipe axis on the base material in the region subjected to said peening treatment.

(6) A method for reinforcing a steel pipe pole base according to the item (4) or (5), characterized by applying said peening treatment by ultrasonic vibration under the conditions of 20 to 50 μm in amplitude and several tens of kHz in frequency.

As mentioned above, in the present invention, peening treatment is applied by ultrasonic vibration to the weld toes of inverted-U or inverted-V shaped ribs formed by bending the upper end portions of tabular ribs welded to a steel pipe pole base in the form of a T-joint. The method employed for the peening treatment is a method wherein a cylindrical tool is ultrasonicalls vibrated in the axis direction, the tip of the vibrating cylindrical tool is applied to the surface of an objective metal and, by so doing, the surface is made concave. This method makes it possible to strengthen a steel pipe pole base by imposing a high level energy on a metal surface, thus producing plastic deformation, relaxing stress concentration, and imposing residual compressive stress on a weld toe.

Further, in the present invention, by employing inverted-U or inverted-V shaped ribs as mentioned above, the upper end portions of the ribs are liberated from the principal stress direction of a steel pipe pole to a direction perpendicular to the principal stress direction and the rigidity of the rib upper end portions is lowered. As a result of this, it is possible to considerably relax stress concentration produced at weld toes, when bending stress is imposed on a steel pipe

pole, and also the residual tensile stress caused by welding heat.

Furthermore, in the present invention, a peening treatment is applied to the weld toes of ribs by ultrasonic vibration. The method employed for the peening treatment is a method wherein a cylindrical tool is ultrasonically vibrated in the axis direction, the tip of the vibrating cylindrical tool is applied to the surface of an objective metal, and by so doing the surface is concaved. In consequence, a high level energy is imposed on the weld toes, plastic deformation is produced, and residual compressive stress is imposed. For this reason, the weld toes that have been the weak points of a steel pipe pole base are further strengthened and therefore it becomes possible to suppress the deterioration of strength at the weld toes of ribs and prevent the deterioration of the proof stress and the fatigue property, of boxing welded portions at the upper end portions of the ribs, even when a repeated bending moment is imposed on a steel pipe pole.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a perspective view showing the first embodiment according to the present invention.

Figure 2 is views explaining a portion subjected to peening treatment by ultrasonic vibration in the first embodiment shown in Figure 1; Figure 2(a) is a side view, 2(b) a front view and 2(c) a perspective view.

Figure 3 is a front view showing the second embodiment according to the present invention.

Figure 4 is a perspective view showing the third embodiment according to the present invention.

Figure 5 is a stress concentration profile obtained by subjecting a steel pipe pole base to which an inverted-U shaped rib is attached to FEM analysis.

Figure 6 is a stress concentration profile obtained by subjecting a steel pipe pole base having a conventional construction to FEM analysis.

Figure 7 is S-N curves showing the results of fatigue strength tests in the case of Example 1.

Figure 8 is S-N curves showing the results of fatigue strength tests in the case of Example 2.

Figure 9 is a side view of an ultrasonic impact device.

Figure 10 is a perspective view showing a conventional example.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Firstly, a steel pipe pole base reinforced with tabular ribs according to the present invention is explained hereunder.

In Figure 1, reference numeral 10 denotes a steel pipe pole used as a street light support pole, a road sign support pole or the like, 11 a base plate welded to the lower end portion of the steel pipe pole 10, 12 a plurality of ribs welded in the form of a T-joint for the reinforcement between the steel pipe pole 10 and the base plate 11. Each of the ribs 12 is tabular and cut obliquely at the upper end portion and forms a triangular rib. Then, in the case of a road pole, the steel pipe pole 10 is vertically supported by fixing the base plate 11 to a skeleton made of concrete by using anchor bolts 15. The above configuration is the same as a conventional one.

In the present invention, a peening processed portion 20 subjected to ultrasonic vibration is formed at the weld toe 16 of each tabular rib 12 as shown in Figure 2. The peening treatment by ultrasonic vibration is applied by the method as shown in Figure 9 wherein the tip of a cylindrical tool 22 of an ultrasonic impact device 21 is applied to the surface of an objective metal, is ultrasonicalls vibrated in the axis direction, and by so doing makes the surface concave.

The tip of the cylindrical tool 22 generally has a round section and a preferable diameter thereof is about 1 to 6 mm. The reason is that, when a diameter is less

than 1 mm, the strength is insufficient and enough impact cannot be imposed, and, in contrast, when a diameter exceeds 6 mm, the mass is too large and therefore ultrasonic vibration is hardly generated.

A preferable frequency of the cylindrical tool 22 is in the range from 10 to 50 kHz and a preferable value of amplitude thereof is in the range from 20 to 50 μm. The reason for regulating the frequency as above is that a large impact energy can be imposed efficiently on a steel material in that frequency range. When a value of amplitude is less than 20 μm, a sufficient impact cannot be imposed. On the other hand, when a value of amplitude exceeds 50 μm, the plastic deformation of a steel material undesirably increases excessively in some cases.

A metal surface processed under the aforementioned conditions undergoes plastic deformation by a high level energy, is made concave to a depth of about 0.1 to 0.5 mm, and a tensile stress can be introduced up to the depth of 10 mm or more from the surface. Further, the metallographic structure changes largely up to the depth of about 100 μm from the surface, a texture layer called a white layer is formed, and good corrosion resistance, good wear resistance and the reduction of friction resistance can be obtained.

In the present invention, such a peening processed portion 20 subjected to ultrasonic vibration as mentioned above is formed at the weld toe 16 of each tabular rib 12 as shown in Figure 2. It is preferable to form the peening processed portion 20 at a portion from the upper end portion of the rib 12 to at least about 10 mm downward. As a result, the stress concentration at the weld toe 16 is relaxed, a tensile stress is imposed on the weld toe 16, and the fatigue strength improves remarkably. Further, though the weld toe 16 of a rib 12 is a portion where structural detects are likely to occur by the combined effect of residual tensile stress and the

degraded heat-affected zone caused by welding heat as mentioned above, even structural defects such as fine cracks can be remedied by changing the microstructure by applying peening treatment by ultrasonic vibration.

Next, a steel pipe pole base reinforced with inverted-U or inverted-V shaped ribs bent at the upper end portions according to the present invention is explained hereunder.

In Figure 3, reference numeral 10 denotes a steel pipe pole used as a street light support pole, a road sigh support pole or the like, 11 a base plate welded to the lower end portion of the steel pipe pole 10, 13 a plurality of inverted-U shaped ribs welded in the form of a T-joint for the reinforcement between the steel pipe pole 10 and the base plate 11. Here, the inverted-U shaped ribs 13 may be replaced with inverted-V shaped ribs 14 as shown in Figure 4. The base plate 11 is fixed to a skeleton such as a road by using anchor bolts 15 and the steel pipe pole 10 is supported vertically.

The steel pipe pole 10 undergoes the principal stress in the vertical direction and the ribs 13 or 14 also stretch as a whole in the principal stress direction of the steel pipe pole 10. However, the upper portion of each of the ribs 13 is bent gradually in the shape of a circular arc and the upper end portion 16 of each of the ribs 13 that forms a weld toe is bent to the extent of forming a right angle with the direction of the principal stress of the steel pipe pole 10.

In this way, by gradually bending the upper end portion 16 of each rib 13 in such a direction as to be liberated from the principal stress direction of a steel pipe pole 10, the upper end portion 16 of each rib 13 can be formed into a structure having a low rigidity. As a result, stress concentration at the upper end portion 16 of each rib 13 is relaxed, residual weld thermal stress at a weld is also relaxed greatly, and the proof stress and the fatigue property as a welded structure are

improved considerably.

In order for these effects to be achieved sufficiently, it is preferable that the radius of curvature at the upper end portion 16 of each rib 13 is set at not less than three times the thickness of the rib 13. If the radius of curvature is less than the above value, the material quality tends to deteriorate when a rib 13 is bent and also the effect of lowering the rigidity is lessened.

Here, Figures 5 and 6 show stress concentration profiles obtained by subjecting a steel pipe pole base shown in Figure 3 and a conventional steel pipe pole base shown in Figure 10 to FEM analysis. Each of those profiles shows by contour lines the distribution of stress generated in the vicinity of a rib 13 or 14 when a horizontal load is equally applied to the upper end portion of a steel pipe pole 10 and the unit of the numerals in each profile is MPa. It can be understood, from a comparison between Figures 5 and 6, the maximum value of stress concentration is reduced up to half that of a conventional structure by bending the upper end portion 16 of a rib 13.

Note that the arrows in the upper right direction shown in Figures 7 and 8 mean that the loading was terminated since no change in the specimens was observed at the time. Further, the expression "n = 2" means that the number of the specimens is two. In this regard, the weld quality of the partial specimens used in the tests is of a very high grade and therefore the fatigue life may possibly be shortened to some extent at the ordinary industrial production level.

Moreover, in the present invention, the weld toe of each of the bent ribs 13 is further subjected to peening treatment by ultrasonic vibration. A peening processed portion 20 is defined by the region extending at the central angle α on both sides of the center line of the rib 13 as shown extendedly in Figure 3 and a preferable

angle α is generally in the range from 30 to 60 degrees. The angle α in Figure 3 is about 45 degrees.

In this way, in the steel pipe pole base according to the method of the present invention, as the weld toe of each of the inverted-U shaped ribs 13 or the inverted-V shaped ribs 14 bent at the upper end portions 16 is subjected to peening treatment by ultrasonic vibration, the effects of those constituents are combined together. As a result, it is possible to considerably relaxation stress concentration generated in the vicinity of the weld toe of each of the ribs 13 or 14 when a bending moment is imposed on a steel pipe pole 10 due to wind, vibration or the like, and to conspicuously improve the fatigue strength at the portion as shown in the data of the examples described later.

Further, it is generally acceptable to apply peening treatment by applying the tip of a cylindrical tool 22 of an ultrasonic impact device 21 to the weld toe of each of ribs 12, 13 or 14 welded to the base of a steel pipe pole 10. However, it is also acceptable to apply peening treatment by ultrasonic vibration while a load (a bending load for example) is imposed on a steel pipe pole base so that a tensile stress in the steel pipe axis direction is applied to the base material in the treatment region. In this way, by applying peening treatment to and imposing a compressive stress on a weld toe while a tensile stress is imposed by externally given force, it becomes possible to make a far larger compressive stress remain at the weld toe 16 when the externally given force is removed. Consequently, a far more excellent reinforcing effect can be obtained.

Though peening treatment is applied by ultrasonic vibration to only the weld toe of each of the ribs 12, 13 or 14 in the above explanations, needless to say, it is also acceptable to apply peening treatment to other welded portions. However, it is estimated that the

application of peening treatment to the lower portions or the like of the ribs 12, 13 or 14 is not practically beneficial because the portions do not directly affect the fatigue strength of the steel pipe pole base.

Example 1

Fatigue strength tests were carried out by imposing repeated tensile stress on partial specimens around steel pipe ribs having the construction shown in Figure 1. The material used for both the steel pipes and the ribs was SM 490. The fatigue property of the conventional construction having as-welded ribs as shown in Figure 10 corresponded to the E to D grades of the design life curves in the "Railway Bridge Design Guideline" as shown by the black round marks in Figure 7. On the contrary, the fatigue property of the invention construction wherein peening treatment was applied to weld toes by ultrasonic vibration markedly improved up to the grade B or higher of the design life curves as shown by the white round marks in the figure. Here, the amplitude of the tool tip was 40 μm and the frequency thereof was 30 kHz.

Further, when peening treatment was applied by ultrasonic vibration while a load for applying tensile stress was imposed on a steel pipe pole base, the fatigue property improved up to the grade A of the design life curves as shown by the black triangular mark. Moreover, even when peening treatment was applied to the weld toe where fatigue cracks were generated by ultrasonic vibration, the fatigue property improved up to the grade A of the design life curves as shown by the white triangular marks. The data show that peening treatment by ultrasonic vibration has the function of remedying fatigue cracks.

Example 2

Fatigue strength tests were carried out by using a test device and imposing repeated tensile stress on the steel pipe pole bases according to the present invention as shown in Figures 3 and 4. The material used for both

the steel pipes and the ribs was SM 490. In comparison, fatigue strength tests were carried out by imposing repeated tensile stress on partial specimens around steel pipe base ribs having the construction shown in Figure 10. As a result, the fatigue property of the conventional construction shown in Figure 10 corresponded to the E to D grades of the design life curves in the "Railway Bridge Design Guideline" as shown by the black round marks in Figure 8. On the contrary, the fatigue property of the invention construction markedly improved up to the grade A of the design life curves as shown by the white round marks in the figure. Here, the amplitude of the tool tip was 40 μm and the frequency thereof was 30 kHz.

Further, when peening treatment was applied by ultrasonic vibration while a load for applying tensile stress was imposed on a steel pipe pole base, the fatigue property improved up to the A grade or higher of the design life curves as shown by the white triangular marks.